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STUDIES ON THE RELATIONSHIP BETWEEN ENCHYTRAEIDS AND EARTHWORMS

M. GÓRNY

Department of Soil Science, University of Agriculture,
Warsaw, Poland

On the eastern Flevoland polder /the Netherlands/ experiments were carried out by van Rhee /1969a,b, 1970/ by introduction of earthworms to the newly reclaimed soil, to accelerate the succession within orchard polder soil communities.

The populations of earthworm Allolobophora caliginosa and Lumbricus terrestris were found as good colonizers, adaptable to their new enviroment. But the introduction of earthworms neither led to better growth of trees /except their roots/, nor to higher yield of fruits /van Rhee 1971/.

The idea of our studies was to obtain some characteristics on enchytraeid worms which were regarded as part of the natural community of the freshly drained soil.

It was supposed also by studying enchytraeids that some knowledge would be gained on the changes in polder soil community after earthworm inoculation which might explain the reciprocal relationships between these two groups of annelids.

MATERIAL AND METHODS

The studies were performed 5 years after establishing the apple orchard in the freshly reclaimed polder soil and 5 years after earthworm inoculation. The sandy clay soil had a pH of 7.4 - 7.6 and 3.5 per cent of organic matter. Apple trees were planted in clean-weeded strips. Grass was mown several times a year and put on the tree strips for mulching.

The samples for enchytraeid evaluation were taken from the plots /10 m^2 each/ established by van Rhee /1969a/ in two orchards situated one next to the other /Fig. 1/.

Ten cores were taken from each plot where the earthworms were introduced and ten cores from each control plot. The cores of 200 cm^3 of soil /5 cm diameter and 10 cm deep/ were taken in undisturbed condition to the laboratory, where they were divided into four subcores of 2.5 cm each. The sampling procedure was provided on the suggestion of Górny /1981/. The enchytraeid worms were extracted from subcores during four hours in an O'Connor /1962/ apparatus.

RESULTS

Species composition. From the 957 specimens of enchytraeids found in the polder soil, there were only 58 fully mature forms and among them 49 of *Henlea ventriculosa*, 4 of *Fridericia ratzeli* and 3 of *F. callosa*. The two not yet fully mature specimens of *Lumbricillus* were determined as *L. tuba*. From the remaining immature specimens 729 were determined as *Henlea* sp., 109 as *Lumbricillus* sp. and 52 as *Fridericia* sp. It is very probable that most of the young specimens are of the same species as the four determined.

Horizontal distribution. The highest density of enchytraeids was found on control plots, and rather scarcy on plots with earthworms. The differences in the number of worms were not only between inoculated and control plots but also between orchard A and orchard B /Table 1/.

In orchard B 30 per cent more enchytraeids were found than in the soil of orchard A. In both plantations the soil was similar. Although there were no differences in the development of apple trees, their growth, shoot length and in yield, the production of roots of the trees was a little higher in orchard B. The content of organic matter was similar, too, but the volume of pore space and the air content in the soil was a little higher in orchard B /van Rhee 1971/. This may imply that the higher density of enchytraeid worms found in orchard B was probably due to better aeration of the soil.

Table 1

Horizontal distribution and density of enchytraeids

	Orchard A		Orchard B	
	A	C	AL	C
Henlea sp.	4,300 /30/	14,400	200 /1/	20,450
Fridericia sp.	–	1,100	750 /68/	1,100
Lumbricillus sp.	200 /5/	3,650	–	1,700
Total	4,500 /23/	19,150	950 /41/	23,250
Maximal number of specimens per sq.m	20,000	36,000	5500	48,000

Figures in parentheses = per cent

A - plots inoculated with *Allolobophora caliginosa*

AL - plots inoculated with *A. caliginosa* and *Lumbricus terrestris*

C - control plots

Table 2

Vertical distribution of enchytraeids /number of specimens per sq.m/

Soil layer	Orchard A		Orchard B	
	A	C	AL	C
0 - 5	3750 /83/	16,550 /86/	750 /79/	20,800 /89/
0 - 10	750 /17/	2,600 /14/	200 /21/	2,450 /11/
Total	4500 /100/	19,150 /100/	950 /100/	23,250 /100/

Figures in parentheses = per cent

Table 3

World distribution of enchytraeid species found in the Flevoland polder

Species	Site and authors
Fridericia ratzeli	forest /Nurminen 1967, Abrahamsen 1968, Kasprzak 1973/
	meadow /Abrahamsen 1968
	cave /Kasprzak 1973/
	littoral /Tynen and Nurminen 1969/
Fridericia callosa	seaweed at the beech /Nielsen and Christensen 1959, Abrahamsen 1968, Tynen and Nurminen 1969/
	forest /Nurminen 1967, Abrahamsen 1968, Kasprzak 1973/
Henlea ventriculosa	forest /Nurminen 1967, Abrahamsen 1968, Kasprzak 1973/
	arable land /Abrahamsen 1968, Ryl 1975/
	littoral /Tynen and Nurminen 1969, Legeżyński 1971/
	well-water /Kasprzak 1973/
Lumbricillus tuba	littoral /Tynen and Nurminen 1969/
	wet site /Nielsen and Christensen 1959/

With the t-test it was found that the differences between inoculated and control plots in enchytraeid number of orchards A and B were highly significant: $t>3.1$, $p<0.002$ and $t>3.92$, $p<0.001$, respectively.

This testing made it possible to consider that in the examined soils with earthworms, the enchytraeids were less numerous than in the soil without earthworms /control plots/. An additional conclusion is that the least enchytraeids were found on plots where two species of earthworms /*A. caliginosa* and *L. terrestris*/ were inoculated.

However, these conclusions may be used with precaution only, when treated generally. The situation in Table 1 was mainly influenced by the dominant *Henlea* sp. and in some cases *Lumbricillus* sp., the distribution of which was similar. Another was the distribution of *Fridericia* sp. But neither specimen of *Lumbricillus* or *Fridericia* has been found in adequate numbers allowing for statistical calculation.

The vertical distribution of enchytraeid worms was similar on plots with earthworms and on control ones. Of the enchytraeid population 79-89 per cent was found in the upper 5 cm of the soil profile /Table 2/. Therefore it is doubtful whether the earthworms with their burrowing activity facilitate the penetration of deeper layers of the soil by potworms. In addition, a similar vertical distribution was observed among the dominants *Henlea* sp. and two other genera, *Lumbricillus* sp. and *Fridericia* sp.

RESULTS AND DISCUSSION

As it was mentioned before, the population of enchytraeids on control plots was dense and the worms were of good condition, i.e. they were well adapted to their new terrestrial environment. Dominant were the worms of *Henlea ventriculosa*. The specimens of this species make up for 75-88 per cent of the whole population.

Many authors mentioned *H. ventriculosa* and *F. ratzeli* as widely distributed in a variety of habitats and *F. callosa* and *L. tuba* as species characteristic of wet sites. But the last two species have been found also in other sites and all the four species /*H. ventriculosa*, *F. ratzeli*, *F. callosa* and *L. tuba*/ /Tynen and Nurminen 1969/ are mentioned among the European littoral fauna.

Therefore it is possible to assume that all species found in the new terrestrial soil on polder are more or less eurytopic.

The enchytraeids belong, among others because of their cocoon dispersal, to the primary natural components of new soil transformed from littoral to terrestrial. The development of their populations shows that the new polder soil was biologically not as "undeveloped" as it had seemed.

The results of our studies show that every bioamelioration operation should be preceded by exactly distinguishing the chemical, physical and biological soil properties.

The fact that the enchytraeid population was built of a few species with one dominant should be seen as a characteristic status within this group of soil animals. But the composition of the species found, with semiterrestrial ones among them, was not typical of terrestrial soils and showed that the polder community had not yet reached its climax stage in its successional development.

The introduction of earthworms to the polder soil caused changes in the natural soil community, both in species composition, abundance and activity. After earthworm inoculation the population of potworms as a whole diminished to 23-41 per cent compared to the control plots /Table 1/. In this case the introduction of one group of decomposers /earthworms/ led to diminishing of the other /enchytraeids/. Enchytraeids and earthworms generally have a similar role in the soil, but their ecological status is different.

It was found that enchytraeids were unable to burrow canals and did not use earthworm canals for penetrating deeper layers of the soil. The reason for such a reaction has not been clarified yet.

It is widely known that every species by excreting substances to its surrounding causes changes and is responsible for specific "conditioning" of the soil. This was probably also the case with earthworms. Such "conditioning" of earthworms may affect not only enchytraeid worms, but is probably responsible for other changes, also positive ones, by influencing the species composition, the density and activity of other soil organisms.

Therefore, the introduction of one or two species to the existing community should be treated as a hazardous operation.

It was supposed that antagonistic effects on enchytraeids were mainly connected with secretions and/or with excrements. However, from the data of Table 1 it may be seen that the antagonistic interrelations do not exist between the two families, earthworms and enchytraeids, but are of interspecific character. This hypothesis is now being tested in the laboratory.

In our field experiment the introduced species of earthworms occupied at least a part of site niches of enchytraeids, which obviously shows that the estimation of the number and the size of pores in the soil is not sufficient for predicting the space for a defined group of organisms. The possible useful space for soil fauna should be determined by estimating a complex of factors and among them the specific relations between different species. But this needs to be further developed in soil biology.

From this point of view, the lack of any yield effects after the introduction of earthworms to the well developed community in polder soil should be seen as the result of the deficiency of knowledge rather than to misinterpreting soil factors. Therefore it should be stressed that, although the efforts to introduce earthworms were economically not feasible, they provide for interesting and useful ecological information.

Finally, the great importance of such unique environments as polder soil for biological studies should be emphasized.

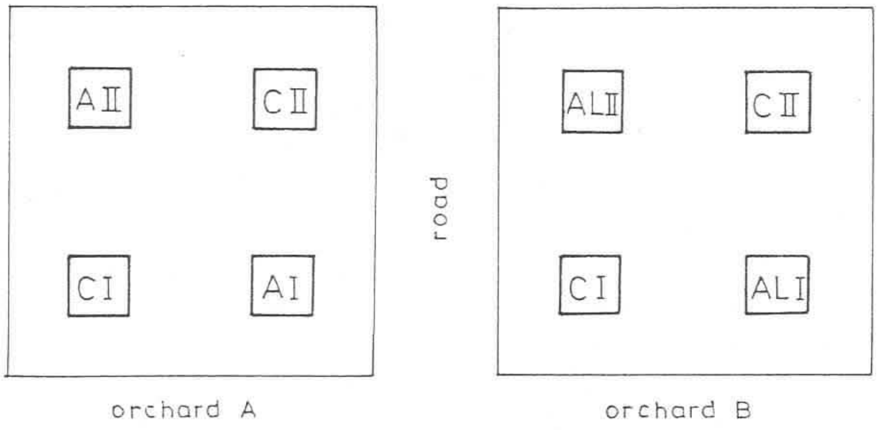

Fig. 1. Distribution of plots on two study areas. A - plots inoculated with Allolobophora caliginosa; AL - plots inoculated with A. caliginosa and Lumbricus terrestris; C - control plots; I, II - repetitions

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